EVOLUTION IN THE VEGETABLE KINGDOM.

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(Continued from p. 644, July number.)

II. Geological View.

The most ancient fossil remains that have been referred to the vegetable kingdom are two species of Oldhamia from the Cambrian deposits of Ireland, but the vegetable character of these forms has been latterly called in question. From the Lower Silurian forty-four species, chiefly marine algæ, have been named. Among these, however, are included the earliest terrestrial forms. Not to mention the problematical *Eopteris morierei* of Saporta, we have *Sphenophyllum primævum* Lx., and two other vascular plants from the Cincinnati group. In the Upper Silurian thirteen species are recorded, five of which are vascular plants. One of these is *Cordaites robbii* Dawson, found in the Silurian of Hérault as well as in the Devonian of Canada. The Devonian furnishes 188 species of fossil plants, while from the Permo-Carboniferous nearly two thousand species are known, or nearly nine-tenths of the entire Palæozoic flora.

With the Mesozoic a great diminution appears in the abundance of vegetable life that has been preserved. Only sixty-seven species have been found in the whole of the Trias. With the Rhætic a new impulse is felt increasing through the Lias and reaching a second but much reduced maximum in the Oölite, from which 419 species are recorded. The wave then again recedes until the close of the Gault is reached.

The Cenomanian of Europe, with the beds of Atane in Greenland and the Dakota group of the United States which probably correspond to it, mark a new epoch, supplying together nearly five hundred species of fossil plants. That member of the Cretaceous formation which immediately overlies the Cenomanian, viz., the Turonian, to which the Fort Benton group of American rocks seems to belong, is almost destitute in both countries of vegetable remains, but with the Senonian we meet again the increasing volume which was merely interrupted by unfavorable conditions for the preservation of plants. Here we have in European strata, in Patoot, Greenland, and in British Columbia 354 species. Although none have yet been described from this horizon within the territory of the United States, I have myself demonstrated

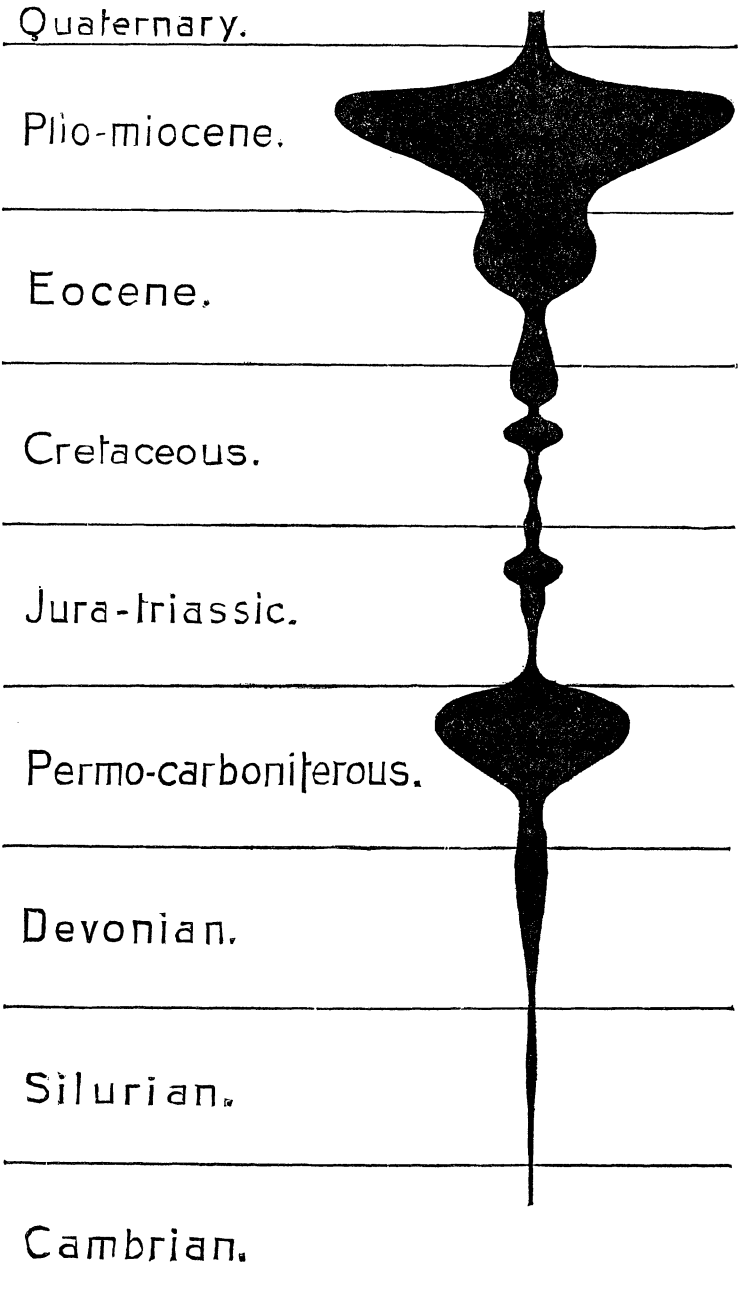
their existence to a limited extent, and live in hopes of yet bringing to light an important Upper Cretaceous flora.

We are thus brought to the Laramie group of the Western Territories, which, though a brackish water deposit and difficult to correlate with other deposits, may be regarded as extreme Upper Cretaceous; 333 species have been thus far described from this group, which presents a flora of a still more Tertiary aspect than that of the Senonian proper, and fittingly ushers in the Tertiary flora.

From the Paleocene of Sézanne and Gelinden to the Miocene the progress is uniform and rapid. The Eocene of the old world (Paris basin, Aix in Provence, Monte Bolca, Monte Promina, Monte Pastello, Isle of Wight, London clay, etc.) furnishes over 650 species, while the Green River group of America, including the rich beds of Florissant, Colorado, probably of that age, has yielded more than two hundred. This is exclusive of the so-called Oligocene of the continent (Hæring in Tyrol, Sotzka in Carniola, the Marseilles basin, Armissan near Narbonne, etc.) from which nearly 800 more have been taken. We thus have over 1800 pre-Miocene Tertiary plants, which is, however, much less than half of the Tertiary flora. The Miocene supplies nearly all the rest, yielding alone over 3000 species. It may be, as has been charged, that this number is too great, and that a portion of these plants belong to lower horizons. While Heer's determinations in Switzerland have not been seriously questioned, his work on the arctic floras is doubtless open to revision, but this will not diminish the number of Tertiary plants, which, if we add to those already mentioned some 150 Pliocene species, will form an aggregate of nearly 5000.

The Tertiary virtually closes the series for vegetable remains, the Quaternary having thus far furnished less than one hundred species of fossil plants.

The development of plant life through the successive geologic ages may be graphically represented, so far as indicated by actual discovery, by the accompanying diagram or figure, in which the number of accredited species is taken as a measure of predominance, and the space assigned to each horizon in the vertical scale represents its duration in so far as the thickness of the deposits can be regarded as a measure of time.



The fact is thus brought clearly to view that there have existed

two favorable periods for the preservation of vegetable remains—the Carboniferous and the Miocene—the wide interval between which is relieved by two less favorable periods culminating in the Oölite and the Cenomanian respectively. To what extent the intervals of great scarcity may yet be filled, it is impossible to predict, but it is well to remember that it is only quite recently that the Oölite has assumed prominence as a vegetable deposit, and this chiefly through researches made in India and Siberia. With the further development of such outlying regions it is to be hoped that a much greater degree of uniformity in the different geological periods will be secured. But of this there is no certainty, and it is perhaps equally probable that future research may tend to exaggerate the present extremes.

Three things must combine for the successful development of a fossil flora in any given geological formation: 1. The requisite vegetation must have flourished at the period in question; 2. the conditions for its preservation and subsequent exposure must have existed; and 3. the localities in which it is imbedded must be found and worked. As regards the first of these conditions, we know that great fluctuations of the land surface of the globe have taken place, and periods may have been passed during which these were much less in amount than at others. Still, there can be little doubt that the variety at least, if not the abundance of vegetation, has undergone a somewhat uninterrupted increase since the earliest times. The second condition is a much more serious one. Immense periods may have elapsed without any record being made, not because vegetation was scarce, nor because land areas were limited, but because, as seems now to be the case over most of the globe, all vegetation was allowed to decay and return to the atmosphere. Again, vast beds may have been deposited but never afterward raised up and exposed, and may remain forever inaccessible. It is only the third condition which it is within the power of man to influence. But when we consider the accidental manner in which a great part of such discoveries have been made thus far, we may well presume that the most precious scientific treasures which the earth holds may remain undiscovered indefinitely although within the easy reach of the investigator.

III. Botanical View.

Most of the plants of the Palæozoic age belong to archaic types long since extinct and having only very much modified

living representatives. This is less marked in the ferns than in those forms which have as their nearest modern descendants the Equisetaceæ, the Lycopodiaceæ and the Coniferæ. The Palæozoic ancestors of the Equisetaceæ are the Calamariæ, having the genus Calamites for their typical form. Those of the Lycopodiaceæ are the Lepidophytes with Lepidodendron as their type, while according to the most recent researches the Coniferæ had as their ancestral form the Cordaiteæ, long classed among the Cycadaceæ, with Cordaites as the principal genus.

As a means of expressing the fact of this prolongation of living forms through the geologic periods and of denoting the probable descent of modern from these archaic types of vegetation, the terms Filicineæ, Equisetineæ and Lycopodineæ have been employed as broader than the corresponding ordinal designations in common use. The Marquis Saporta has sought to accomplish the same object for the Coniferæ by the term Aciculariæ, but this unfamiliar substitute will not be likely to meet with general acceptance.

The cellular cryptogams, which, admitting Oldhamia to be a plant, had two representatives in the Cambrian, constituted the principal vegetation throughout the Silurian. Yet the ferns, if we accept Saporta's Eopteris, the Equisetineæ and Lycopodineæ, all had their origin in the Lower Silurian, while the Coniferæ, through Cordaites, made their appearance in the Upper Silurian.

Three species of Rhizocarpeæ (Sporangites, Protosalvinia) have been described by Sir J. W. Dawson from spore-cases detected in Devonian rocks of both Canada and Brazil. Heer had already mentioned, in 1874, what he regarded as the fruit of some rhizocarp from the Lower Carboniferous of Spitzbergen, and there can be little doubt that many of the spore-bearing plants of the coal measures belonged to this order, although none have been described from the Carboniferous proper. This little group, which has been supposed in a manner to mark the transition from the cryptogams to the gymnosperms, reappears, according to Heer, in the Oölite of Siberia, the Urgonian of Kome and the Cenomanian of Atane, Greenland. It occurs in our Laramie and Green River groups, in the Oligocene of France, and in the Miocene of Switzerland and Central Europe.

With the true Carboniferous two new types appear—the Cycadaceæ and the monocotyledons. If, with Grand'Eury, we rele-

gate the Medullosæ to the ferns, the former of these types has a meager representation, but Renault admits Cycadoxylon in that formation, and *Cyclocladia ornata* occurs at Saarbrücken, while Schenk finds a true Pterophyllum in the coal flora of China.

The presence of monocotyledons in the Carboniferous was long disputed, based as it was upon certain palm-like trunks described by Corda from Radnitz. But we now have one species of Palæospathe whose monocotyledonous character has not been questioned. The problematical sporangium, too, formerly supposed to occur no lower than the Permian, has now been found in the Carboniferous of St. Etienne, of Wettin, of Mazon creek, Illinois, and of Pittston, Pennsylvania, while so skeptical an author as Nathorst, in one of his latest works, defends its claims to be called a monocotyledon.

Thus we find that all the leading groups or types of vegetation, except the dicotyledons, had made their appearance at the close of the Carboniferous age. Before passing to that important subclass of the vegetable kingdom, the Ligulatæ and the Gnetaceæ, though numerically unimportant, deserve notice because they have been regarded by some as transition forms connecting the great types.

The Ligulatæ are allied to the Lycopodiaceæ, and the genus Selaginella has sometimes been placed in the one and sometimes in the other of these orders. It is claimed to have been found in the Carboniferous, but of this there is doubt. Its first certain appearance is in the Cenomanian beds of Atane, Greenland, but it also occurs in our Laramie group at Golden, Colorado, and at Point of Rocks station in Wyoming Territory. The more typical ligulate genus, Isoetes, makes its first appearance in our Eocene at Florissant, Colorado, and is represented by two Miocene species in Europe.

As regards the Gnetaceæ, by far the most ancient known representative is Heer's *Ephedrites antiquus*, from the Oölite of Siberia. Only two other fossil species of this order are known, viz., *Ephedra (Ephedrites) sotzkiana* (which not only occurs in the Oligocene of Sotzka, but in several of the principal Miocene beds of Switzerland, Germany and Austria) and *Ephedra johniana* from the amber deposits of Samland, Prussia.

The immense interval of time that separates the first appearance of all other forms of plant life from that of the dicotyledons

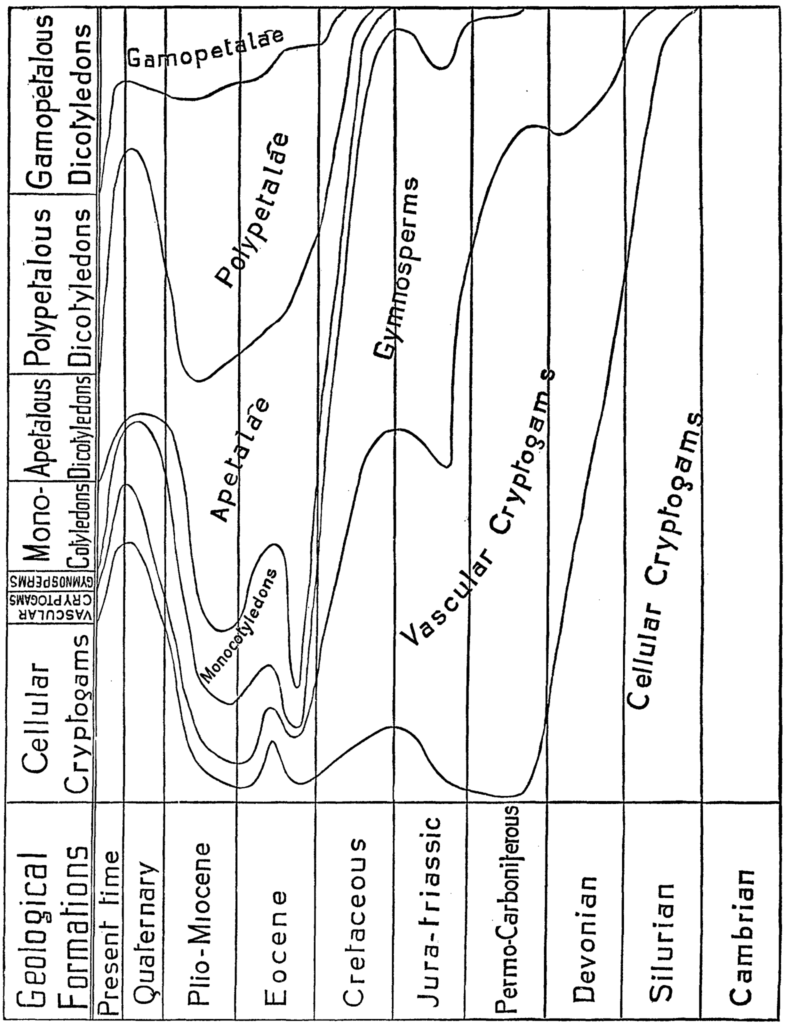
is one of the most striking facts revealed by palæontology. Heer's *Populus primæva*, from the Urgonian of Pattorfik, Greenland, described ten years ago, still remains the sole representative of this sub-class in any formation below the Cenomanian and the most ancient dicotyledon known.[1] Not less remarkable, however, has been the march of these plants since their earliest manifestation, as will presently be shown.

Having thus noted the time of first appearance of each principal type of vegetation, we may now hastily glance at the mode oi subsequent development of each. This might be done from two distinct points of view, the absolute and the relative, but as the former would be powerfully affected by the defects in the geological record, no attempt will be here made to represent it graphically. The relative point of view, however, admits of such representation which in a certain respect eliminates these defects. Collectors of fossil plants do not seek specially for particular types. They take all they find, and hence if the chances of preservation are equal for all types the chances of finding plants of a particular type would depend upon its abundance in the flora of the epoch to be studied, while conversely, the degree to which any type of plants is represented in collections would be a fair measure of its abundance in the flora of the given epoch. The accompanying diagram is based upon this assumption, and clearly shows the progress of each of the leading types.

The facts sustain in a striking manner the early generalization of Brongniart, against which Dr. Lindley so strongly inveighed as late as 1836, that there has been a general upward tendency in structural development through the geological periods. The Silurian was the age of cellular cryptogams, consisting principally of marine Algæ. The reign of the vascular cryptogams began with the Devonian and closed with the Permian, the ferns constantly taking the lead but being strongly supported by the Calamariæ and Lepidophytes throughout the Carboniferous. The gymnosperms assumed supremacy in the Trias, the Cycada-

[1] Fossil wood supposed to possess the dicotyledonous structure has several times been found in lower formations (see J. G. Kurr's "Beiträge zur fossilen Flora der Jura-formation Württemberg," Stuttgart, 1845, page 9; Sorby "On the occurrence of non-gymnospermous exogenous wood in the Lias near Bristol," Microsc. Soc. Trans., III, 1852, pp. 91–92), but evidence of this class is not yet accepted as conclusive.

ceæ taking the lead in the Keuper and holding it through the Oölite, then surrendering it to the Coniferæ, which held it far up into the Lower Cretaceous. The monocotyledons never held a dominant position but increased steadily throughout the Meso-



zoic, reaching their highest expression in the palms and their greatest relative predominance in the Eocene, but probably attaining their highest absolute development in the Oligocene or Lower Miocene. The dicotyledons, which, as already shown, made their first observed appearance in the Urgonian, or Lower Cretaceous,

progressed with such amazing rapidity as to become the ruling type in the Cenomanian, or Middle Cretaceous, furnishing in that formation over seventy-two per cent of the total known flora of the globe, which is nearly as high a percentage as they attained at any subsequent period. Of the present flora they form less than sixty per cent, and doubtless their relative position in the fossil flora is exaggerated, owing to the failure of the myriad fungoid forms, existing then as now, to leave any traces in the rocks.

The systematic value of the prevailing subdivision of the dicotyledons into monochlamydeous and dichlamydeous, and the latter again into polypetalous and gamopetalous, diminishes with the progress of research. The first of these divisions is invalidated by the fact that the natural affinities are between apetalous and polypetalous and not between apetalous and gamopetalous plants, the last named division being the highest in point of structural development. The apetalous division forms forty-five per cent of the dicotyledons in the Cenomanian, thirty-seven per cent in the Miocene and only fourteen per cent in the living flora. The polypetalæ are fifty per cent in the Cenomanian, forty-eight per cent in the Miocene and forty per cent in the living flora. The Gamopetalæ are five per cent in the Cenomanian, fifteen per cent in the Miocene and forty-six per cent in the living flora. Making all due allowance for the fact that the Gamopetalæ of the living flora are more largely herbaceous than either of the other divisions, which fact, properly viewed, constitutes a strong proof of their greater recency, this evidence would seem quite sufficient to establish the order of development of the dicotyledons as here arranged.

As still further confirming the general law of development in vegetable life, we observe the great decline of the cryptogamic types that predominated throughout the Palæozoic. The same is true to a less extent of the gymnosperms, and notably of the Cycadaceæ. The monocotyledons have also probably declined, as have the lower or monochlamydeous dicotyledons. The only one of all the leading forms of life of which we can positively say that it still preserves an upward tendency is the gamopetalous division of the dicotyledons, which, unless arrested by human agency, seems destined to form the dominant type of vegetation or the next geologic epoch.